Puzzle

TANKS

TEACHER'S GUIDE

TI-73

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Thomas C. O'Brien is a former professor at Southern Illinois University, Edwardsville, Illinois. His work in education is three-fold: teacher education, curriculum development and research on children's thinking. As a researcher, he has studied the growth of mathematical ideas in subjects from pre-school to medical school and law school. As a teacher, he has worked with students from the seventh grade through graduate school. As a curriculum developer, he has written twelve math-problem books for children, as well as written and edited some eighty papers on children's thinking and education published through the Teachers' Center Project.

In addition, Dr. O'Brien has published and delivered some 100 papers on children's thinking, mathematics education, intellectual development and educational change. His papers and presentations have taken place in the United States, Canada, Great Britain, Holland, France, Switzerland, Hungary and Brazil. Dr. O'Brien was named a North Atlantic Treaty Organization (NATO) Senior Research Fellow-in-Science in 1978. He received his bachelor's degree from Iona College, New Rochelle, NY, and his Ph.D. from New York University.

Other Sunburst programs designed by Thomas O'Brien include: *Teasers by Tobbs, Tobbs Learns Algebra, The King's Rule, The Royal Rules, Blockers and Finders, Blockers and Finders II, Winker's World of Patterns, Winker's World of Numbers, More Teasers by Tobbs, Teasers by Tobbs with Integers* and *Label Land.*

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INTRODUCTION

Suppose you have the following problem:

> You have two tanks, one of which holds 5 quarts and the other 6. You have an infinite supply of Wonder Juice and a holding container into which you could pour the contents of the tanks. You must use the original tanks — the 5 and 6 — to make 11 quarts of Wonder Juice.
>
> Easy. Fill the 5 and the 6 and empty them into the holding tank.

Why do a problem like this? Such a problem calls for children to develop and/or apply addition skills and to view addition in its very essence. Addition is not reciting responses from memory. Addition involves combining things.

Here's another problem:

> Suppose you have the same 5 and 6 tanks and this time you need 2 quarts of Wonder Juice. Not so easy, is it? You could fill the 6 and pour it into the 5, thus leaving 1. Save the 1 in the holding container. Then empty the 5. Can you finish the problem?

This isn't an exercise in addition facts. What is it? It's problem solving, one of the most important abilities one can have.

Problem solving takes place when one reassembles (or creates) actions and ideas to achieve a goal in a new situation. We are all problem solvers every day, and we are all more or less successful at problem solving. But problem-solving abilities are too important to leave to chance and the random experiences of everyday life. Problem solving needs special attention.

Much of the school curriculum purports to promote problem solving. The National Council of Teachers of Mathematics chose problem solving as its issue for teachers to pursue in the 1980's. Present-day school children will live most of their lives in the twenty-first century. What new issues will they face? No doubt, facts will be important to them, but they'll meet novelty and challenge and opportunities presently unknown to us. (Some of you are old enough to remember when Dick Tracy's wrist radio was unspeakably futuristic. Do you remember — it's just over 35 years ago — when a man on the moon was unthinkable? Can you think back to the time when a computer in a private home was not so commonplace?)

A major aspect of life is novelty — dealing with new situations for which you've not been programmed. What do you do? You create your own solutions. You become a problem solver. Problem solving is, and should be, a major objective in schools and the home.

But problem solving in math textbooks is often falsely named. "Problems" in most math textbooks aren't really problems. They are computational exercises disguised in words: "Two boys each ate 4 hamburgers…." Such activities are trivial so far as problem solving is concerned, and they are trivial from the point of view of utility. I haven't had to solve a "word problem" in the last thirty years of my adult life, but during the same time, I have met and solved dozens of problems every day.

What does problem solving involve? Hofstadter says it nicely in Godel, Escher, Bach:

- to respond to situations flexibly;
- to take advantage of fortuitous circumstances;
- to find similarities between situations despite differences that may separate them;
- to synthesize new concepts by taking old concepts and putting them together in new ways; and
- to come up with novel ideas.

Puzzle Tanks then, is concerned with problem solving in the Hofstadter sense. It is concerned with children's ability — and willingness and confidence — to make sense out of a situation and devise alternatives to reach a goal. The construction of alternatives, not the repeating of pat formulas, is what thinking and problem solving are all about.

About *Puzzle Tanks*

How does *Puzzle Tanks* create a good educational environment?
It deals with issues that are important. Problem solving is important.

It enables the student to be active — to invent ideas, to try them out and, if necessary, to revise them. The very nature of *Puzzle Tanks* is that players invent solutions and revise them. Mistakes, by the way, are okay. (Can you conceive of an infant learning to walk without lots of falls at the beginning?)

It adds diversity. At each level of *Puzzle Tanks*, what worked for the last problem is unlikely to work for the next. Further, every individual problem has many different solutions. There is no such thing as "the one right way."

It has a wide variety of entry points and a high ceiling. *Puzzle Tanks* starts with very simple problems, such as the $5 + 6 = 11$ task described earlier, but the higher level problems have stumped some very bright, well educated people.

Thus, *Puzzle Tanks* puts kids in real problem-solving situations with real lifelong payoffs.

GETTING STARTED

Hardware and Software Requirements

MAKE SURE YOU HAVE THE FOLLOWING ITEMS:

- TI-GRAPH LINK™ computer-to-calculator cable. If you do not have a TI-GRAPH LINK cable, call Sunburst, or order the cable online at the TI Accessory Store (www.ti.com/calc/docs/store.htm).
- Connecting TI-GRAPH LINK cable adapter, 9-pin to 25-pin, if needed.
- Computer with Windows® 3.1x or Windows® 95/98 installed. (A Windows NT® version will soon be available.)
- *Puzzle Tanks* software for the TI-73 on disk.
- A TI-73 calculator.

THINGS TO CHECK BEFORE YOU BEGIN

To make sure the batteries in your TI-73 are in good working condition, turn on your TI-73. If there is a low-battery message on the screen, turn the TI-73 off and follow the battery replacement procedure in Appendix C of your TI-73 Guidebook.

Before you load *Puzzle Tanks* into your TI-73, verify that sufficient free space exists in your application memory space by entering 2nd MEM, 3:Check APPs. The first line indicates the number of free spaces available. Most applications will take up only one space. See the Memory is Full instructions in the Trouble Shooting Section for details about deleting applications.

Installing *Puzzle Tanks* on a TI-73

NOTE:
The TI-73 may briefly display a "Defragmenting" message. This simply means the calculator is preparing for downloading.

1. Make sure the TI-GRAPH LINK cable is firmly connected to the calculator and the computer and the calculator is at the home screen.
2. Start Windows and close all desktop applications that may be running (another running application could interfere while *Puzzle Tanks* is updating your TI-73).
3. Select Run from the File menu (Windows® 3.1) or Run from the Start menu (Windows® 95). In the Run dialog box, type C:*directoryname*\\ti73puzz.exe (where *directoryname* is the directory to which you downloaded the Puzzle Tanks file) and then click OK.
4. Follow the on-screen instructions to complete the installation.

IMPORTANT: DO NOT interrupt the installation process. If any errors are encountered during the installation, follow the instructions. Error Recovery instructions are also described in the Trouble Shooting Section of this guide.
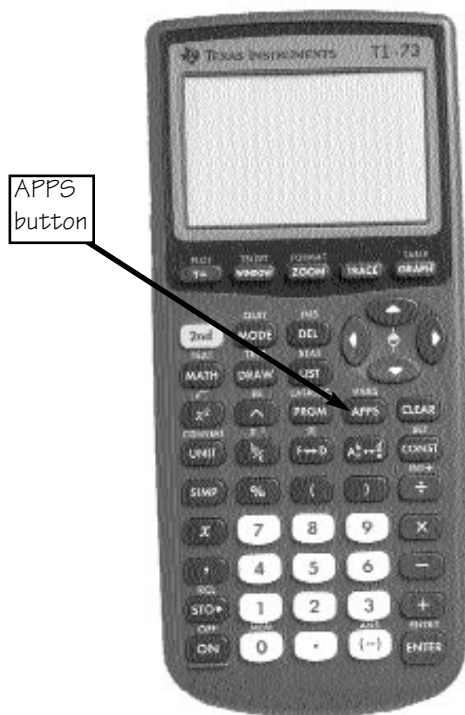
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PROGRAM DESCRIPTION

Welcome to *Puzzle Tanks*

The following section takes you through a sample game of *Puzzle Tanks*.

APPS
button

After installation is complete, find and press the APPS button located on the calculator below and to the left of the down arrow. The Applications screen will appear.


```
1:Link…
2:BUILDING
3:PUZTANKS
4:SAFARI
```

On the Applications screen use the arrow keys to scroll down and highlight PUZTANKS or press the number that corresponds with the PUZ-TANKS. In the above example, *Puzzle Tanks* is the third application on the calculator. In this case pressing 3 will launch the application.

At the credits screen press any key to continue. You will be prompted to enter your name.

NOTE:
Names may be a maximum of 8 characters long. Also, you may use the number keys when entering a name.


```
PUZZLE TANKS
Enter your name:

  A B C D E F G H I
  J K L M N O P Q R
  S T U V W X Y Z -

ADD | DEL | CLR |    | DONE
```
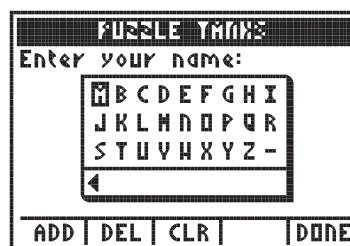
Use the arrow keys to navigate among the letters on the alphabet chart. The **ADD** option in the menu bar allows you to select the highlighted letters. The **DEL** option in the menu bar allows you to delete the last letter selected. Once you have finished entering your name, use the **DONE** option in the menu bar to go to the Main screen.

Use the arrow keys and the enter key to select the level of play you'd like to start with. To familiarize yourself with the game, you may want to choose the Beginner level first.
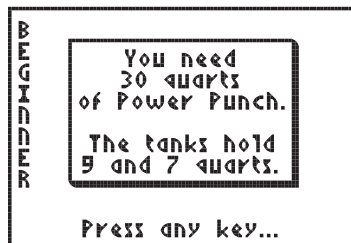
```
PUZZLE TANKS
   BEGINNER
    EXPERT
    MASTER
   CHAMPION
  DIRECTIONS
     QUIT
```

Once you choose the level you want, a problem will be presented. After you've read the problem, press any key to begin solving it.

NOTE:
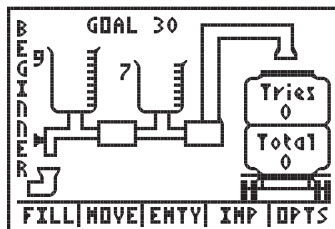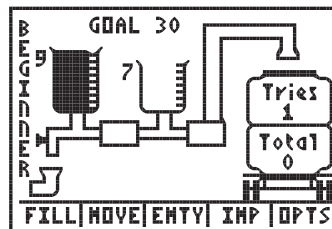You always have an unlimited supply of liquid with which to fill the tanks.

```
BEGINNER
        You need
        30 quarts
        of Power Punch.

        The tanks hold
        9 and 7 quarts.

        Press any key...
```
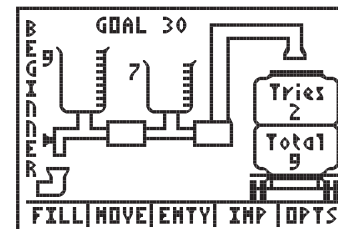
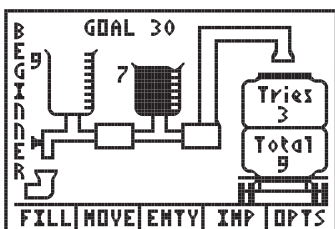A solution to this problem is shown in the following steps:
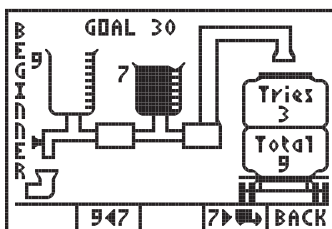
Graphic representation of the problem.
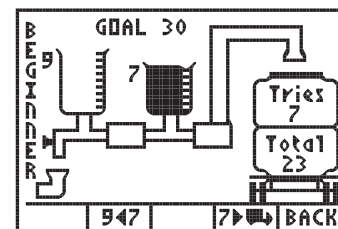
Fill the 9-quart tank.

Move the contents of the 9-quart tank into the truck.

Fill the 7-quart tank

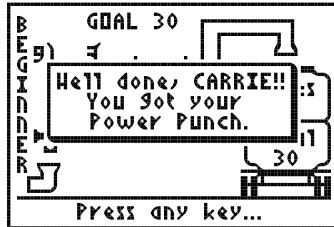Move the contents of the 7-quart tank into the truck.

Fill the 7-quart tank 2 more times, each time moving the contents to the truck.

PROGRAM DESCRIPTION

The congratulatory screen will appear when you solve the problem.

```
          GOAL 30
B
E
G                  .    .
I
N   |Well done, CARRIE!!|  :S
N   |  You got your     |
E   |  Power Punch.     |  i1
R                           30

        Press any key...
```

When you feel you have mastered the level at which you started, move on to the next level for a greater challenge.

Finding Your Way Around *Puzzle Tanks*

You will use the main menu bar located at the bottom of the screen to interact with *Puzzle Tanks*. The five keys directly below the game screen (hereafter referred to as the Master keys) correspond directly to the five items in the menu bar. Filling and emptying tanks, or moving liquid between tanks, can all be accomplished using these keys. For example, pressing the Y= key on the calculator will activate the **FILL** option in the menu bar.

Below is a description of each of these options.

- **FILL** causes a new menu bar to appear with options to fill either of the tanks with liquid. **BACK** is provided to take you back to the main menu bar if you do not wish to fill any tanks after all.

- **MOVE** causes a new menu bar to appear with options to move liquid from one tank to another, or to move the liquid from one tank into the truck. **BACK** is provided to take you back to the main menu bar if you do not wish to move any liquid.

- **EMTY** causes a new menu bar to appear with options to empty either of the tanks that contain liquid. **BACK** is provided to take you back to the main menu bar if you do not wish to empty either of the tanks.

- **IMP** Indicates if a problem is impossible or not. A congratulatory message will appear if you are correct. If the problem is possible, a message will appear indicating the problem can be solved. In either case, you will be charged one try in the Tries section of the screen.

- **OPTS** activates a dialog box offering the following choices: either starting a new game or replaying the same game, going to the main menu, getting directions, viewing the champion list, or quitting the application.

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SCORING

The program keeps track of the number of moves or "tries" used to solve each problem. That number is shown along with the goal amount in a box located on the right side of the game screen. In the Champion level, this number is recorded, and the player who solves the problem in the least number of tries is listed as the champion for that problem.

HOW TO PLAY

In *Puzzle Tanks*, you are given the option to choose from four levels of play: Beginner, Expert, Master and Champion. Each level increases in difficulty. The tanks are chosen at random from 1 to 9 units; the goal amount is also chosen at random.

First, enter your name; then select a level of play. After you have selected a level of play, you will be presented with a problem. Press any key to continue. A graphic illustration of the elements in the problem will be displayed on the screen. You can attempt to solve the problem by filling tanks, emptying tanks, and moving liquids between the tanks or into the truck (depending on the level of play) by using the options in the menu bar.

LEVELS OF PLAY
Beginner Level
In the Beginner level, the problems involve simple addition, subtraction and multiplication. Here is an example:

Given a 9 and a 3, make 12	(Addition)
Given a 9 and a 3, make 6	(Subtraction)
Given a 9 and a 3, make 27	(Multiplication. Three 9's.)
Given a 9 and a 3, make 21	(Multiplication and addition-Two 9's plus a 3.)

In summary, if one tank holds "a" and the other holds "b," Beginner level problems use the following formulas:

- $a+b$
- $a-b$
- $k \times a$ (e.g., $3 \times a$)
- $k \times a + c \times b$ (e.g., $2 \times a + 6 \times b$—two of one tank and six of another tank will fill the truck)

PROGRAM DESCRIPTION

Expert Level

In the expert level the problems are more challenging. Suppose you had tanks holding units of 6 and 5, and the goal is 8. There could be a couple of different solutions:

> You could do 6 - 5 eight times, emptying each of the remaining units into the truck.
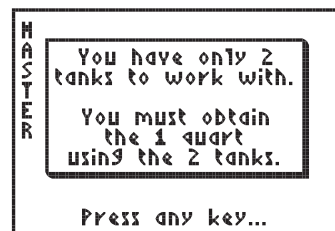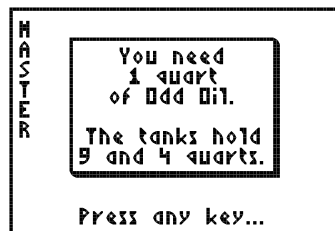>
> Or you could do 6 + 1 + 1.

Can you think of other solutions?
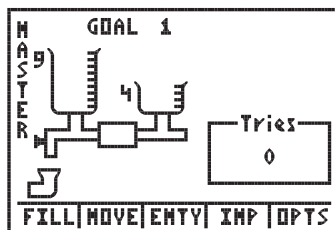
Master Level

At the Master level, the situation changes completely—there's no truck for storage! One must obtain the target amount with only the two tanks provided. Here's an example of a Master problem:
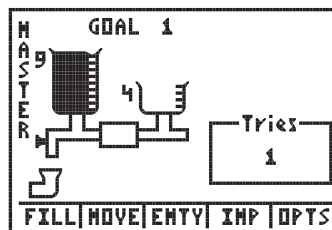
```
M                            M
A     You need               A    You have only 2
S     1 quart                S    tanks to work with.
T     of Odd Oil.            T
E                            E    You must obtain
R     The tanks hold         R      the 1 quart
      9 and 4 quarts.             using the 2 tanks.

      Press any key...            Press any key...
```

Here is a solution:

```
M     GOAL  1        M     GOAL  1        M     GOAL  1
A  9                 A  9                 A  9
S        4           S        4           S        4
T             Tries  T             Tries  T             Tries
E               0    E               1    E               2
R                    R                    R
  FILL|MOVE|EMTY| IMP |OPTS   FILL|MOVE|EMTY| IMP |OPTS   FILL|MOVE|EMTY| IMP |OPTS
```
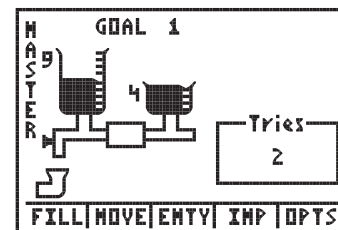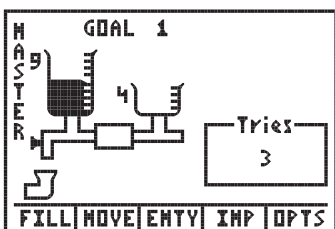
Graphic representation of the problem. / Fill the 9-quart tank. / Move the contents of the 9-quart tank to the 4-quart tank.

```
M     GOAL  1        M     GOAL  1        M     GOAL  1
A  9                 A  9                 A  9
S        4           S        4           S        4
T             Tries  T             Tries  T             Tries
E               3    E               4    E               5
R                    R                    R
  FILL|MOVE|EMTY| IMP |OPTS   FILL|MOVE|EMTY| IMP |OPTS                      |OPTS
```

Empty the 4-quart tank. / Move the contents of the 9-quart tank into the 4-quart tank. / Empty the 4-quart tank and you are left with 1 quart!
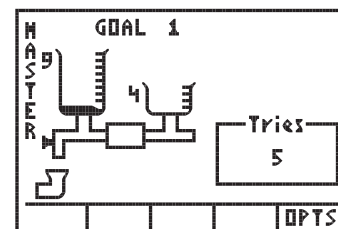
The goal was 1, so the problem was solved in five steps. Is there a solution with fewer steps?

Champion Level

Champion is the most challenging level of play. At this level, you may be presented with a problem that has already been solved by another player who is the champion for that problem. This gives you the opportunity to try to solve the problem in as many or fewer steps than your "opponent."

If there is no champion for the problem, it will be noted on the opening screen describing the problem: "No one holds the championship." If there is a champion for the current problem, the opening screen will give you the name of the player holding the current championship and how many tries were required to solve the problem.

If you succeed in getting the better score or tying the current champion, then you become the new champion, and the score is recorded on the Champion list.

IMPOSSIBLE PROBLEMS

To add an extra challenge to the Expert and Master levels of play, some of the problems are impossible to solve. For example, try to use a 2 and a 6 to make 1. It can't be done. With a 2 and a 6, only 2, 4, 6, 8, 10, etc., are attainable goals. In general, if the two tanks share a divisor (e.g., tanks of 3 and 9, 6 and 8, 2 and 10), only multiples of that divisor are possible. If the tanks share no common divisor other than 1, the sky's the limit! For example, tanks of 3 and 5 can be used to obtain 1, 2, 3, 4, etc.

CHAMPION LIST

The Champion List is accessible from the OPTS menu in the menu bar of each game. It can be accessed anytime during or at the end of a game. The Champion List holds and stores the names of the "champs" who were able to correctly answer the Champion Level problems. The list contains the goal and tank sizes, the names of the champs and how many tries they used to complete the problem.

PROGRAM DESCRIPTION

You can scroll through the Champion List using the arrow keys on the calculator. The menu bar in the Champion List screen contains 3 options; **PLAY**, **CLR** and **CANCL**. If you see a game you would like to play, use the arrows to highlight that game and select **PLAY** from the menu bar. The game will then open and you will have a chance to become the new champion. To reset any of the games in the Champion List back to No Champ simply use the arrow keys to highlight the game and select **CLR** from the menu bar. If you only went into the Champion List to look around, use the **CANCL** option in the menu bar to take you back to the screen where you were previously.

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TROUBLE SHOOTING

Error Recovery Instructions For the TI-73

Communication Error

This error indicates the Flash Installer is unable to communicate with the TI-73. The problem is usually associated with the TI-GRAPH LINK ™ cable and its connection to the TI-73 and/or to the computer. Make sure the cable is firmly pushed into the calculator and the computer.

If this does not correct the problem, try a different TI-GRAPH LINK cable and reboot your computer. If you continue to get this error, please contact 1-800-TI-CARES (see Technical Support).

Memory is Full

This download error appears when the TI-73 contains one to four applications that occupy the available 64K of space. In order to make room for another application, you must delete one from the TI-73. Before deleting an application from the TI-73, you can back it up by using the Windows Backup App command in TI-GRAPH LINK for the TI-73. Once saved, you can reload it to the TI-73 later using TI-GRAPH LINK.

Expiration Date Reached

The application has reached its expiration date and can no longer be used. Please contact 1-800-TI-CARES (see Technical Support).

Miscellaneous Error Received

Write down the error code displayed in the dialog box and contact 1-800-TI-CARES (see Technical Support).

Checksum Error

Exit the installer and try it again. If this problem persists, contact 1-800-TI-CARES (see Technical Support).

Low Battery Condition

It's a good idea to make sure that you have sufficient battery power prior to attempting a download. Low battery indication is shown on the initial screen. If you receive this error during an installation, change the batteries before trying again.
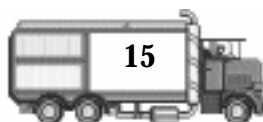
Miscellaneous

If you obtain new or upgraded software for your TI-73, you may need to provide your current software version and/or the serial number of your unit. It is also good to know your version number in case you have difficulties with your TI-73 and need to contact technical support. Knowing the software version may make it easier to diagnose the problem.

Knowing the available number of application spaces in advance helps you better manage your application downloads.

Verify Maintenance Upgrade Version

On the TI-73, enter 2nd, Mem, 1:About. The version number has the format x.yyyy.

Verify Application Version number

On the TI-73, select APPS. Select the appropriate application and press ENTER. The version number of the application appears on the initial screen.

Verify Serial Number

On the TI-73, enter 2nd, Mem, 1:About. The serial number appears on the line beneath the product ID number.

Check Amount of Flash Application Free Space

On the TI-73, select 2nd, MEM, 3:Check APPs. The number to the right of "Spaces Free:" indicates the number of spaces available for applications. Each application requires one space. There are a maximum of four free spaces.

Technical Support

For questions concerning the installation of Puzzle Tanks on your TI-73 or for questions concerning the TI-73 calculator, contact Texas Instruments Customer Support.

Customers in the U.S., Canada, Puerto Rico and the Virgin Islands
     Send us e-mail at ti-cares@ti.com.
     Call us at 1-800-TI-CARES (1-800-842-2737)

Customers outside the U.S., Canada, Puerto Rico and the Virgin Islands
     Send us e-mail at ti-cares@ti.com.